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ON

MODERN CARRIAGE-WAYS:

BEING

A PAPER

READ BEFORE THE

SHEFFIELD LITERARY AND PHILOSOPHICAL SOCIETY,

ON FRIDAY, NOV. 3RD, 1843;

BY WILLIAM LEE,

ASSISTANT SURVEYOR OF HIGHWAYS.

[PUBLISHED AT THE REQUEST OF THE SOCIETY.]

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ON MODERN CARRIAGE-WAYS.

In the early part of the year, I was requested by the President to read a paper on *Roads*, and promised to occupy the May meeting. Unforeseen circumstances prevented my doing so; and, having had no leisure to write a paper on any geological subject, I beg to make such compensation as may be afforded by the present essay.

The subject of 'Roads' is a large one, and presents itself under a variety of aspects.

If we turn our attention to the prætorian, consular, and vicinal roads of the Roman empire, or read, almost incredulous, of ancient roads in Mexico and Peru, constructed of large squared blocks of stone, and carried like our modern railways along continued levels, with tunnels, viaducts, and marks of division into distances, corresponding with our mile-stones; or return to our own country in which ancient roads are still existing, and even ordinarily frequented, many of them of a far earlier origin than anything for which we are indebted to the Romans, we shall find few subjects more interesting than roads, even as an object of antiquarian and historical research.

To the political economist, 'roads' are the veins along which flow the life-blood of the body politic. They are evidences of the civilization of the country, at the same time that they influence largely the extension and advance of that civilization. Without the means of safe and easy communication, between places at a distance from each other, a nation cannot attain to commercial greatness, or enjoy the pleasure which results from an interchange of the arts and elegancies of life. "Let us travel," says Raynal, "over all the countries of the earth, and whereever we find no facilities for travelling from a city to a town, or from a village to a hamlet, we may pronounce the people to be barbarians;" and Dr. Anderson, speaking of the value of roads, says, "Around every market-place, you may suppose a number of concentric circles to be drawn, within each of which certain articles become marketable which were not so before, and thus become the sources of wealth and prosperity to many individuals. Diminish the expense of carriage but one farthing, and you widen the circles: you form as it were a new creation, not only of stones, earth, and trees, and plants, but of men also, and what is more, of industry and happiness."

The law of highways, both common and statute law; how ways may be claimed, by prescription, by grant, or from necessity; how they may be used; the liability to repair, by acceptance, by act of Parliament, or *ratione tenuræ*,—would have supplied abundant valuable matter for an essay, while a glance at some of the important indictments, pleadings, and judgments for damages, and for non-repair, would have furnished much entertainment for the curious.

The draining, or filling up, of fen or morass; the raising of vallies; the cutting down of hills; making the crooked straight, and the rough places plain, are all within the province of the road-maker, and exhibit some of the greatest triumphs of engineering skill opposed to natural obstacles. Bridges, viaducts, aqueducts, tunnels, canals, and railroads, footways, horsepaths, and carriage-ways, are only different species of one genus—"Roads."

To the antiquary and historian therefore, to the political economist, the lawyer, and the civil engineer, the subject has special interesting features; whilst to all, to the merchant; the traveller for health, pleasure, or on business; to the wandering minstrel, or the occupant of a palace; to him who would communicate his thoughts to a distant relative or friend, and equally to him whose happiness is dependent on a due receipt of the morning news; to the lover of his country, and of his kind, good roads form a subject of interest and importance.

Amidst so many kindred considerations, I had to cast about for some view, which would be completed in one paper, and to consider also what would most likely be expected from me: if, therefore, in treating of modern carriage-ways, I have chosen a less attractive portion of the subject, it has been in the hope that more practical information would be conveyed.

The planning and forming new lines of road will not come within the scope of this paper. I shall confine myself to a consideration of the various kinds of road-surface now opposed to the wear of cattle and carriages. I shall conclude as modern all kinds of carriage-ways used, or brought into use, since the time when Mr. Jas. McAdam promulgated his views, and shall treat of them in the following order:—

I. Macadamised or broken-stone roads.
II. Various modifications of broken-stone roads.
III. Boulder or rubble pavement.
IV. Square stone or ashler pavement.
V. Wood pavement.

Of each of these, I shall briefly consider—

1. The mode of construction.
2. The original cost or first outlay.
3. The durability.
4. The advantages; and
5. The disadvantages.

The most common kind of carriage-way in cities and towns, thirty or forty years ago, was a rough *pavement*, formed where suitable material could be obtained of ill-shapen stones, called "rubble" or "randoms," but in places where deposits of gravel existed, of the rounded stones called boulders.

These roads were durable, but uneven, and as the art of carriage-building had not attained to great perfection, a constant and very unpleasant motion was communicated to all who were compelled by business to ride, or forbidden by their rank to walk; and as the latter were the most numerous occupiers of vehicles in towns, especially in the metropolis, and moreover were the aristocracy of the land, they were predisposed to effect by their influence any change in the condition of the carriage-ways, that promised more ease and comfort.

About that time appeared Mr. McAdam before a committee of the Legislature and proposed a remedy. It was not, however, as many suppose, his invention, but had been long practised in Sweden, Switzerland, and other countries. The plan was simple, and bid fair to remove all jolting and inconvenience; this was "a consummation devoutly to be wished," and it was determined that the experiment should be immediately made. Straightway the paving-stones were torn up, broken small, and spread over the streets of London; it was easy to do; the stones were there, and nothing but labour was required; the cities and towns followed the example of the metropolis, the villages and hamlets followed the towns, and England was Macadamised.

Mr. McAdam's mode of construction is to break the stones to about the weight of six ounces, and to spread them upon the road, until the depth is seven to ten inches, with a convexity of three inches to 18 feet, taking care, by constant raking, to keep the road free from ruts, until the materials are consolidated.

The following rules are extracted from his publications:—

"That a foundation, or bottoming, of large stones is unnecessary *and injurious* on any kind of subsoil.

"That the maximum strength or depth of metal requisite for any road is only ten inches.

"That free-stone will make as good a road as any other kind of stone.

"That it is no matter whether the substratum be soft or hard."

Nay, he goes farther, and actually says that five tons of stone upon a marshy foundation, laid seven to ten inches thick, make as good a road as seven tons of stone laid upon a very hard foundation.

These doctrines are completely at variance with the first principles of science, and though still very prevalent, are exploded by all eminent road-makers. Their absurdity was first practically shewn by Mr. Telford, on the Holyhead road.

With respect to a paved foundation: about three years since, during an extensive alteration upon the Park road, near the Gin-stables, I paved the foundation of the road with large stones, five to eight inches deep, in the form of a longitudinal section of a truncated cone. It must be evident that the component stones of this pavement, having broader bases to stand upon than those that are broken small, are not so liable to be pressed into the earth below, particularly where the road is soft. This was covered with coatings of small stones about twelve inches thick. I was compelled soon afterwards to make a sough to the lower end of the paved portion of the road to draw off the water. the pavement acting as an underground drain, and keeping the crust of the road comparatively dry. That is now the most firm and substantial part of the road.

It has also been fully proved, that where the traffic is considerable, ten inches are not sufficient for the thickness of a road. I have seen very frequently, in the winter season, a sinking under the wheels of loaded carriages, where I knew the road to be twelve inches thick; and in excavating Macadamised roads, to substitute pavement, have frequently found the stones at twelve inches deep completely rounded. Elasticity includes motion, which wears off the angles of the stones, and is incompatible with firmness and durability.

Nothing can be more absurd than to state that "free-stone will make as good a road as any other kind of stone," or "that it is no matter whether the substratum be soft or hard." The very existence of a road depends upon its hardness and non-elasticity. If the inevitable inference from Mr. McAdam's doctrine be true, that an even surface only is necessary, a harrowed field would be equal to an iron railroad. It must be evident, that if a road be elastic, however hard the surface metal may be, the wheels of carriages will be always in a hollow, and a corresponding portion of the moving power will be consumed to overcome the elasticity. The draught must also be much greater from the resistance of a road formed of soft material.

The force of traction is always in an inverse ratio to the strength and hardness of a road.

The following are the results of experiments :—On a well-made pavement, the power required to draw a waggon is 33 pounds; on a road made with six inches of broken stone of great hardness, laid on a foundation of large stones, set in the form of a pavement, the power required is 46 pounds; on a road made with a thick coating of broken stone, laid on earth, the power required is 65 pounds; and on a road made with a thick coating of gravel, laid on earth, the power required is 147 pounds.

In the Report of the Parliamentary Committee on Roads, proprietors of coaches state that upon the gravel roads in the neighbourhood of London, so beautiful in appearance and so pleasant to the traveller, horses of superior strength are rendered useless in the short space of three years.

The most suitable size for stones is 2¼ to 2½ inches diameter, according to quality, and the convexity adopted by scientific road-makers is six to seven inches in 27 feet.

The materials, of course, differ according to the mineral productions of the locality in which the roads are situated; but it by no means follows, that the best roads are in the neighbourhood of the best material. In many places where good materials are abundant and cheap, the roads are rough, loose, and extremely expensive.

The original cost, when the system was introduced, would not be great for the reason already mentioned, namely, the breaking up of the old pavements; but the cost of making a new broken-stone road (not according to Mr. McAdam, but upon the best principle,) the surface being already prepared, would vary from one-half to two-thirds the cost of square pavement with similar material. A road well constructed with broken limestone would cost here about 2s. 8d. per superficial yard.

The destruction of a road is due more to the feet of horses than to the wheels of carriages. Mr. Gordon has calculated that a set of tires would run 3000 miles in good weather, and 2700 miles in average weather; but that a set of horses' shoes would bear only 200 miles of travel.

The durability of broken-stone roads, even of the best kind, is less than that of any other kind of road, the cost of maintaining them in a good state of repair being at least twenty to six, as compared with a road well paved with the same kind of stone. The following facts will shew this:—On a road within this township, where sandstone pavement has cost in the aggregate 4s. 6d. per yard during the last ten years, a portion Macadamized with the best limestone and gannister has cost one shilling per yard annually. Now, upon another road, I have ascertained that, as a material for Macadamizing, limestone will last at least three times as long as the best sandstone, and the presumption is, that in pavement, the proportion would be the same; but allowing only twice as long, we should have upon the same road limestone as pavement for twenty years, the cost six shillings, including repairs, and limestone as a Macadamized road, for the same period, twenty shillings. All the information we can obtain from scientific road surveyors in other towns leads to the same conclusion.

Travellers upon a good, well-set, broken-stone road, experience fewer shocks than upon any other kind of road, excepting wood pavement; but in consequence of the rapid wear, they continue so only for a short time; repairs are very frequent, and there can be few things of common occurrence more unpleasant than the being compelled to plough through a newly stoned road.

The traction being also, as already stated, much greater than on a paved road, the horses have to endure proportionately greater fatigue.

The term "setting" of a Macadamized road is known to be that process by which the loose coating of stones is reduced to a firm, solid crust. This operation is effected by moisture, and by the attrition of wheels, which roll and press and crush the material, until each stone has assumed that form, and obtained that position, which is the least liable to motion. During the first stage of the process, the angles are worn down by continual friction, the force being applied to the loose stones in an oblique direction, compounded of the gravity of the vehicle, and the moving power. As soon, however, as the stones become stationary, crushing commences, the interstitial vacancies become filled with chippings and broken fragments, and the road is set. It is obvious that a surface, somewhat elastic, imperfectly coherent, and already partially pulverised, must undergo very rapid destruction, and become the fruitful source of dust in summer, and mire in winter.

The *dust nuisance* can only be fully appreciated by those whose premises and goods are necessarily exposed to its searching and injurious effects. To those who have only experienced it upon (and, I may say, within) their persons, it may be interesting to know that, to shopkeepers, the enemy is so formidable that, for the six years preceding 1837, the average annual sum paid for watering and cleansing Oxford street, London, was £3963, or about 2s. 4d. per yard. The watering, alone, of the streets of Gravesend, for the year ending the 24th June, 1843, cost one-third of the whole amount expended in repairs.

The inhalation of dust must also be very injurious to health. Its effects may not be felt by travellers, or mere street passengers, beyond the occasional complaint of being "blinded" or "choked" with dust; but shopkeepers and persons who, during part of the year, continually breathe an atmosphere loaded with it, must be liable to chronic disease, somewhat akin to that known here as "grinder's asthma." It would be important to ascertain the rate of mortality, and the causes of death in some of our crowded metropolitan thoroughfares, where granite dust is generated in large quantities, as compared with other streets where it is unknown. This is, however, a subject of medical police, which would lead us beyond the scope of our present inquiry.*

In the winter season, these roads absorb and retain a large quantity of moisture, which accelerates the grinding process, and also, during frost, expands and lifts the whole surface material. A sudden thaw leaves the road soft, spongy, heavy, and full of mud, which cannot be removed without scraping away part of the material at the same time; and the damage done under such circumstances is almost incredible. During a very unfavourable thaw, several years since, I estimated the deterioration upon the Park road, 1¾ miles, to be, in eight days, more than £200. The mire so rapidly accumulated upon these roads, especially in towns, is a grievous and intolerable nuisance to all classes of society;—to the pedestrian, who vainly endeavours to pick his way decently, on tip-toe, across the street, and is saluted by a spattering from the wheels of some passing vehicle;—to the equestrian, who is in a short time covered with it from head to foot;—to the occupiers of carriages, on each side of whom it is thrown up, by centrifugal motion, as from a fountain of batter;—to the shopkeeper, or inhabitant of a great thoroughfare, whose premises are splashed and daubed to his heart's *dis*content;—and, though last, not least, in his own estimation, to the road surveyor, who knows that roads wear much more rapidly with a coating of mud upon them, and yet cannot always get quit of the nuisance as fast as it is produced.

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* Since writing the above, I have observed, in the Sanitary Report of the Poor Law Commissioners, what had previously escaped my notice, that this subject has engaged the attention of Dr. Arnott.

For all these reasons, and others that might be named, roads Macadamized, or formed with broken stone, ought to be banished from the precincts of every market town in the kingdom.

In the township of Sheffield, containing thirty miles of public road, the extent of Macadamized roads has, during the last eight years, been reduced from 11¼ miles to less than seven miles.

To remove the mud rapidly and effectually, a sweeping machine has been introduced, the invention of Mr. Whitworth, of Manchester; and I had the pleasure to witness its operation the first day it was brought out, in London. It is about the size and form of one of our mud-carts, is drawn generally by two horses, and attended by two men. In the hinder part of the vehicle is a frame of wood, from seven to nine feet long, and about three feet wide, placed at an angle of about forty degrees from the road; the lower part nearly touches the ground, and there are sideboards to prevent the escape of the mud in that direction. Over, but in contact with this frame, is an endless chain of long, narrow brushes, which revolves rapidly, sweeps the road, and conveys the mud up the inclined plane, at the top of which it drops into the body of the carriage. The wheels are the propelling power. It requires only five minutes to fill, and, as far as taking up the mud, does its work effectually. But the question arises, what is to be done with the cargo? It is impracticable to carry every load away, perhaps several miles, in such an expensive machine, because it would, in that case, only be employed from half an hour to an hour per day as a sweeping machine, and all the rest of the time as a cart. There would, therefore, be so great an amount of wear and tear, if a sufficient number of these machines were employed, as to prevent them from competing with labourers and ordinary carts. What, then, is to be done with the cargo of mud? Why, after marching up hill, it marches down again. As soon as the machine is full, they empty it again upon the road, a greater nuisance to the public than ever, until carts and labourers shall come and take it away. When the march of intellect shall put an end to the formation of mud, by improvements in paving,—or, by pouring all the mire into common sewers, shall obviate the necessity of cartage,—then shall the sweeping machine be the only scavenger. The scheme, although a very ingenious contrivance, wants, at present, an important element of success,—practical usefulness.

Many attempts have been made to remedy the objections to Macadamized roads, the most memorable of which was the introduction, about five years since, of asphalte cement.

The best kind of asphaltic stone is from the valley of Travers, in Prussia, where there are mines belonging to the Count de Sassenay. It is prepared thus: ninety-four parts of the stone (which is calcareous) are pulverized, mixed with six parts of bitumen, and melted in large boilers; the mass is then poured off, and formed into large cakes, which constitute the cement. When about to be used, it is re-melted in a moveable furnace, with broken granite and gravel, and spread in that condition upon the road.

The object was, to cement the stone, without crushing, and, by obtaining a surface impervious to moisture, to pre, vent dust and mud. I had several opportunities of observing it, and found the asphalte wearing down faster than the stone, and also more in one place than another; the surface soon became uneven, and had the appearance of a road paved with small boulders. Its operation was mostly confined to London, where it was used on the Ferry-road, Millwall, Poplar, the Vauxhall road, in Oxford street, and some other places. As usual, many patents were obtained, and several companies formed; but it was soon found unfit to sustain a great traffic, and though still used for footpaths occasionally, has, I believe, entirely disappeared from the public carriage-ways.

A cheaper and more successful application, of a non-absorbent cement, has been used three or four years in Nottingham. I allude to the method of coating broken stone, with gas tar, for which Mr. Thomas Smart, of that town, endeavoured to obtain a patent, but without success. The stone is broken down to two inches in diameter, heated in a furnace, then covered with tar, and afterwards spread over the road, about three inches thick, upon a substratum of ashes or other dry rubbish; it is then rolled with a large cylinder, after which another stratum, of similar material, broken to an inch, or an inch and a half, is laid on, when the rolling is repeated.

The quantity of tar depends upon the absorbing power of the stone; and the facilities for obtaining ashes, stone, and tar, must affect any calculation of the original cost.

The expense, as near as can be stated, would be relatively about one-third more than that of a common Macadamised road.

Its durability is considerably greater. Sufficient time has not yet elapsed since its introduction, to ascertain with certainty; but it will probably last three times as long as the common road.

It is impervious to moisture, and the process of cementation being accomplished with very little crushing, there is scarcely any mud or dust produced.

One peculiarity of this kind of road is, that it can only be laid down properly during the summer season, while the ordinary Macadamised road must be repaired only in winter.

The black colour of these roads is a great disadvantage, especially to carriages travelling in the night.

The effluvium of the tar is very unpleasant during summer, when the road becomes softened by the heat of the sun.

Repairs are with difficulty effected, because the new portion of the composition will not adhere well to the old; and the road is seriously damaged by any alteration of gas or water pipes.

The principal objection, however, is, that these are more elastic than any other kind of carriage-way that I have seen, particularly during the summer season. I examined a piece, about nine months since, then recently laid down upon the Derby road in Nottingham; the road is a steep one, and the surface was smooth and apparently firm; but on enquiring at the Roman Catholic chapel erecting there, I learnt that, since it had been done, an additional horse has been required to draw up the same quantity of building stone.

Thus it will be seen, that this method has some advantages, and many disadvantages. I think it quite unfit for any road with a large up traffic.

A portion of Talbot street, in this town, has been done with it, as an experiment, but owing to the ignorance of the labourers, and my inability to be continually with them, I must confess that it is not a fair specimen of the system.

We now come to the consideration of paved carriage ways.

Randoms and boulders, which for our present purpose may be classed as one, are at the same time the most extensively used in provincial towns, and the most inferior in quality of any kind of pavement.

It is unnecessary in Sheffield to describe the mode of constructing a boulder-pitched road; suffice it to say, that after excavating the soil sufficiently deep, a bed of ashes or sand is formed, with a surface properly curved; and the boulders are rapidly pitched into holes dug out of the soft material with a pavier's hammer, after which the whole is rammed down with a heavy maul.

The original cost here is from ninepence to one shilling per superficial yard; or scarcely one-half that of a good Macadamized road.

An almost invariable rule applies to the shingle on the sea-beach; the diluvium widely spread over the plains of this country, and the local alluvium of almost every valley;—it is, that the sand and fine gravel are the detritus of comparatively *soft* stone, while the *hardest* ONLY have survived the rolling of the waters; and they, in a greater or less degree, with the loss of their previous angular form. Boulders are therefore generally the hardest kind of stone in any locality, and are consequently the most durable.

Boulder pitched roads are frequently out of repair, but repairs are easily and cheaply effected. The expense of repitching a road with the old material is not more than one-third of the original cost; and, although it may appear strange, the road is better than new, because the stones have become faced, and the foundation more firm.

With a given traffic, including the first outlay, the comparative cost of maintaining the carriage ways in Sheffield, for a period of ten years, is, boulders, 2; square stones, 4½; Macadamised, 8½.

The one great advantage of boulder pitching, (and I am not aware of any other,) is, that it forms the most economical of all carriage-ways.

Some of the objections to it are, that the ashes or sand is soon washed away from the joints of the stones, when it becomes very rough, and the jolting is unpleasant for passengers, and injurious to horses. In addition to this, the noise produced by wheels continually passing over the projecting stones is a serious inconvenience to the inhabitants of any street where the traffic is great.

For these reasons, boulder pitching, in large towns, should be confined to streets where the traffic is inconsiderable; to places where there are few sale shops or buildings of the more respectable class; and to roads where economy is an object of the first importance.

The modes of constructing square stone pavement are almost as numerous as the cities and towns where it is in use.

The material used in London is granite, principally from Peterhead, near Edinburgh, from Aberdeen, and from Cornwall, but occasionally from Guernsey.

The stones, or cubes, as they are frequently called, are from seven to nine inches deep, five to eight inches broad, and eight to sixteen inches long. This latitude, as to depth, is not to be found in the same piece of work, but is the general range of the blocks. The form is the same as that used here.

The foundation varies; generally a bed of loose gravel is made, with only a covering of sand; occasionally the gravel is grouted with caustic lime, or other cement; the stones are set loosely upon sand, and the whole is beaten down with a large maul by a labourer who follows the pavier. The final grouting is similar to that practised here.

The original cost of good ordinary pavement is 12s. 3d. per superficial yard. The steep roadway of Blackfriar's Bridge was paved two or three years since with Guernsey granite, which contains less felspar, and is much harder than any other; the stones are eight inches deep, but only three inches wide, and the contract was at the enormous sum of 23s. per superficial yard.

The durability of granite paving-stones, even in the greatest thoroughfares, is astonishing. The following are the results of experiment, and show the period that would be required to wear down *four* inches of stone in Commercial road, with all the traffic of the East and West India Docks:—[*]

Guernsey	90 years
Blue Peterhead	43 "
Red Aberdeen	36 "
Blue Aberdeen	25 "

Under the most favourable circumstances, the pavement would, undoubtedly, require taking up, and resetting during the above period, but the foundation in London is generally so bad, that frequent repairs are necessary.

In Leeds, where the pavements are neither extensive nor good, the best kind is granite from the quarries of Messrs. John Gibb and Sons, of Aberdeen; the mode of construction is the same as in London, but more attention is paid to the foundation.

The cost of pavement, *eight* inches deep, is 13s., and of *nine* inches deep, 14s. per superficial yard.

Its durability, out of London, may be said to be incalculable.

In Manchester and Liverpool, granite has not been extensively used, the great cost of transit preventing its general introduction. The best pavements are mostly constructed of Whinstone, called there "Welsh sets," which are in all respects equal, if not superior, to any granite. The slipperiness of this material has been obviated by reducing the size of the stones to 3 or 4 inches broad, 7 inches deep, and 7 to 10 inches long; and they are now laid with only sufficient convexity to carry off the water.

A substratum of broken stone is formed three inches deep, upon this two inches of gravel, and then the sets, which are pitched and rammed in a manner similar to our boulders; the work is completed by grouting with sharp sand.

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[*] Parnell on Roads, p. 362.

The original cost, including labour, is about 7s. 6d. per yard, and the officers there state, that "in a thoroughfare like Market street, the pavement would stand twenty years without resetting, if not disturbed for the purpose of laying gas or water pipes; and as to the period that would elapse before the stones would be worn out, they have no data upon which to proceed, but so far as they are able to judge, the wear or tear of many years makes little or no impression upon the material."

Excepting Guernsey granite, whinstone is the most durable material known. I do not hesitate to say, that it would require *ten* years in one of our greatest Sheffield thoroughfares, to wear away *one-fourth of an inch*;* and, for the sake of economy, I hope to see them extensively laid down here when the Sheffield and Manchester Railway shall be completed, and at a cost not exceeding 8s. 6d. per yard.

In Nottingham, the material is granite from Mount Sorrel, whence it is conveyed by water, a distance of 19 miles.

The stones are the smallest I have seen, being not more than 5 inches long, 7 inches deep, and 3 inches broad. A bed of fine gravel is formed, and the pitching and ramming is performed in a manner similar to that of boulders. There is no grouting; a thin coat of sand only is spread over the surface. The roads are about as convex as ours in Sheffield.

The original cost is 5s. per superficial yard. Part of Pelham street, a narrow road of as great traffic as any in Nottingham, has been in wear *thirteen* years without resetting, and is in a very good condition. Goose-gate is wider, with about the same amount of traffic; it has been paved about *eight* years, and is now almost as smooth as when first laid down.

I need scarcely say, that the material used in Sheffield for square stone pavements is a hard sandstone, of the lower or gannister coal measures, and is obtained in the neighbourhood. The blocks are 9 inches deep, from 7 to 10 inches broad, and from 11 to 16 inches long. These are set upon a bed of ashes. A distinctive feature in our mode of paving is, that the mason beats down each separate stone with a large mallet, raising or lowering it as occasion may require, and does not leave it until firmly fixed in the proper place; so that the work has all the exactness of the line and rule. The last operation is grouting, with two-thirds sand and one-third lime, mixed with water and poured into the joints.

From what has been already stated, it will be seen that whatever may be the general condition of the streets *here*, as compared with those in other large towns, the square paving stones are very inferior in quality to any of those enumerated, and that the surveyor is placed in the difficult position of having to make and maintain good roads with comparatively bad material.

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* Parnell on Roads, p. 362.

I have frequently attempted to introduce granite, but have found that, from Aberdeen or Mount Sorrel, (the only places at present accessible,) it would be too expensive.

Between two and three years since, the short road behind the Tontine Inn was paved, as an experiment, with the carboniferous limestone of Derbyshire. The stones are from 4 to 7 inches broad, 8 inches deep, and 8 to 15 inches long. When this road was Macadamised with similar material, coatings equal to five inches thick were necessary every winter. Since it was paved, more than two years have elapsed, and the hewing marks are scarcely obliterated from the faces of the stones. By comparison with other roads, where the traffic is similar, it will last probably 40 years. The best sandstone pavement, besides requiring frequent repairs, would be worn out in about 12 years.

A small patch of limestone pavement was also laid down in Russell street, about twelve months since, and an extensive search has recently been made by Mr. Flockton, the Chairman of the Highway Board, and myself, with a view to its becoming the staple material for square paving stones. We have no doubt the enquiry will be successful. We can foresee but one objection that may or may not arise,—*slipperiness.* No complaint has been made of that already done; and the objection may to a great extent be prevented by reducing the dimensions of the stones.

The cost of limestone paving complete is 4s. 10d., and of the best sandstone pavement 3s. 5d. per superficial yard.

The durability of the sandstone may be judged of from the fact, that High street was paved with the best stone 8½ years since; the surface is tolerably even, but it has been frequently repaired, and the stones are now becoming far worn.

The general advantages of square stone pavements may be briefly stated. The traction is less, if they are well constructed, than on any other kind of carriage way (railways, of course, excepted.) They produce less dust and mire than any other road formed of stone; and they are the most economical of all roads, excepting boulders.

The objections urged against them are, that the noise is intolerable to the inhabitants, and that the stones become slippery, and dangerous for cattle and carriages.

Neither of these objections is applicable to the pavements in this town, but to those places where very hard and durable material is used; and the slipperiness has been in a great measure obviated, in Manchester, Liverpool, and Nottingham, by reducing the dimensions of the blocks.

Wood pavement is at the present moment a subject of general interest. It is supposed by many to be a recent invention; it has, however, been long used in other countries, and in some places is the common material for paving the streets.

In England, it was first introduced in the latter part of the year 1838, when a patent was obtained by Mr. Stephen Geary, of Hamerton place, King's cross, London, for hexagon blocks, from 4½ to 9 inches diameter, made of Scotch or Norway fir, placed vertically, and as close as possible to each other. This is the most simple form, and is, I believe, that known as "Stead's patent," Mr. David Stead, the present owner, having purchased it soon after the patent was granted.

Scotch or Norway fir, though soft, is found the most suitable wood for paving, because, after a short time, the fibres become loosened at the surface, and turn over, in a manner similar to the face of the wooden mallets used by our street masons. This avoids two evils—sudden concussion, and its attendant noise.

The first experiment was in Oxford street, in December, 1838. It was laid down, at the same time, with many kinds of granite, used both for paving and Macadamising,—in the latter form with and without the asphalte cement; patches of each being put down, from 20 to 50 yards in length, to take its trial before the inhabitants of the metropolis.

The blocks were about 12 inches deep, and were not bevilled at the edges or grooved; sufficient care was not taken to have the wood uniform in quality, and the substratum was nothing more than loose gravel.

It was soon after put down in a similar manner in the Old Bailey; and in November, 1839, I had an opportunity of witnessing the laying down of the third specimen (in the narrow street leading from High Holborn to Oxford street,) with bevilled edges, but the same foundation as before.

The original cost in all these places was 10s. 6d. per superficial yard; and the contractor undertook to keep it in repair for three years, at *sixpence* per yard per annum.

It was not found to be durable, for want of a hard foundation; the blocks being unconnected with each other, some of them were soon driven down, the surface became uneven, and those that kept their places were rounded and slippery. The whole of it has since been replaced by other pavement, laid upon a hard concrete foundation.

This concrete is a patented invention, without which wood pavement could never have succeeded to any extent. It is composed of a metallic sand, lime, and gravel, mixed with water, and spread evenly over the road. Great care is required to ensure uniform strength; if this be not attained, the pavement will soon fall into dilapidation.

In April last, I examined the concrete in Oxford street, after it had been two years in use, and struck it repeatedly with a heavy iron crow-bar, without making the slightest impression. The gavelock rebounded as if struck upon a large block of stone.

The expense of concrete is about one shilling and sixpence per yard; and since its introduction, the hexagon blocks, improved by additional grooving, have been laid in several places in London; the most perfect specimen is in the Strand, near the Golden Cross.

The depth of the blocks has been reduced to six inches, and as the form is the most simple, the original cost is less than that of any other kind of wood pavement.

It is probably on this account that it has succeeded better in the provinces than any other, while in London, the Metropolitan Company has laid down three-fourths of the aggregate quantity in use.

Immediately on its introduction, a great number of patents were obtained for as many modifications of the general principle. Many of these would never have returned one sixpence into the pockets of the owners, had not a company of speculators simultaneously appeared under the name of "The United Wood Paving Company," with the chivalrous design of buying them all up,—Stead's among the rest. This it accomplished, and died of repletion, when Stead's patent, according to agreement, reverted to him, and I am not aware that any of the others have since been heard of.

In the year 1839, the "The Metropolitan Patent Wood Paving Company" was established, and has confined itself to one patent,—that of Count de Lisle, founded on correct mechanical principles.

The blocks are each *six* inches deep, and *six* inches square on the face, with grooves one-inch wide, and half an inch deep, at right angles. The oblique sides are shaped at the angle, which is found to give the greatest mutual support. The blocks are joined together by oaken dowels in masses of *twenty-four*,—six blocks in length, and four in breadth.

The rows are bevilled alternately in opposite directions, and each mass is further secured along the sides with iron cramps, so that the whole mass resists the pressure on each particular block, and the adjoining masses support each other, because the alternate bevills at the ends form a dove-tailed joint.

This Company has from the first used a concrete substratum, and, so far as a smooth surface is desirable, has always attained its object.

The Company commenced operations in Dec. 1839, by laying down about 1100 yards, in Whitehall, which continues at this moment smooth and level. Since that time, nearly 100,000 yards have been put down by the Company in London;—in Oxford street and the Old Bailey, to replace the hexagons; and in Piccadilly, Jermyn street, Newgate street, Oxford street, Hammersmith bridge, St. Andrews, and St. Giles's, Holborn,- in Lombard street, one side of St. Paul's churchyard, Regent street, and other great thoroughfares. Bishopsgate-street-within has recently been paved by this and another Company; and Cheapside is now nearly completed.

Never shall it be said by grave historian, or "right merrie poet," when writing of some future "John Gilpin," bent on wedding-day excursion,—never again shall it be said—

> "Smack went the whip, round went the wheels,
>   Were never folk so glad;
> The stones did rattle underneath,
>   As if Cheapside were mad."

The original cost, where it has been let by tender, has varied from 12s. 6d. to 13s. per yard, and a further sum of 6d. per yard per annum for maintenance; but the Company has contracted to complete Oxford street at 12s. per yard, to keep it in repair, cleanse, and water it, one year gratuitously, and for twelve years following for the gross sum of £1900 per annum; and further, they are to be paid the first outlay by bonds bearing interest at the rate of four and a half per centum.

It would occupy too much time to mention and describe all the patents that have been obtained. The following are the principal:—Mr. Carey's, used in Cornhill, the Poultry, and Gracechurch street; Mr. Saunders's, in the Strand, near Coutts's bank, and Mr. Rankin's, at St. Giles's church, Holborn.

There are also several other Companies besides the Metropolitan, *i.e.*, the Imperial Wood Paving Company, the General Wood Paving Company; and, within the last few months, the London Wood Paving Company has been established, with a capital of £100,000, to carry into effect the patent of Mr. Perring, the celebrated hatter, in the Strand, who states, in the prospectus of his plan, what had been frequently promised for others, "that it obviates every imperfection that previously existed, both as respects construction and application."

The Imperial Paving Company has two patents, one for square and the other for hexagon blocks. The prices are the same as the Metropolitan, *i.e.*, 4 inches thick, 10s.6d.; 5 inches, 11s. 6d.; and 6 inches, 12s. 6d. per superficial yard.

The General Paving Company's are square, grooved blocks, and the price, for 6 inches deep, is 18s. 6d. per yd.

The great cost of wood pavement, and the serious objections urged against it, have prevented its introduction largely into provincial towns.

Experiments have been made in Leeds with Stead's hexagons, at 9s. 6d.; with the Imperial hexagons, at 12s. 6d.; and the Metropolitan, also at 12s. 6d. per superficial yard.

In Manchester, four to five thousand yards of Stead's hexagons have been laid down; in Lower King street, Deansgate, Piccadilly, opposite the Infirmary, Port street, and in front of the Adelphi Hotel. The Metropolitan Company has paved St. Ann's street and St. Ann's square.

The result is, in the opinion of the authorities there, decidedly in favour of the PRINCIPLE, but until certain objections shall be removed, they "are disposed to believe that for paving purposes no material can be found to surpass the 'Welsh sets.'"

In Liverpool, also, experiments have been made with wood, but it is needless to enumerate further.

The mode of constructing wood pavement will, of course, be the same in the country as in the metropolis. The variation in original cost will be exceedingly small, and the durability will depend entirely upon the amount of traffic where it is used.

I have never heard or read anything more than surmise respecting the durability of wood pavement, either with a given amount of traffic; or, as compared with the durability of granite, and other hard stone; and yet, sufficient data must either already exist, or might be easily obtained in those countries where it has long been the common paving material. Some inference may no doubt be drawn from the fact, that the Metropolitan Company contract to maintain pavement which will cost £14,000—*twelve* years at £1900, or about *one-seventh* per annum; but this is an estimate by which they may either gain or lose considerably and therefore, any conclusion drawn from it would be of little or no value.

Before leaving this part of our subject, it may be well just to state the respective prices at which *Stead's* and the *Metropolitan* (those most extensively used) could be laid in Sheffield.

Depth.	*Stead's Hexagons.*	*Metropolitan Company.*
Six inches	9s. 1½d.	12s. 6d.
Five inches	8s. 0d.	11s. 7½d.
Four inches	6s. 3d.	10s. 7½d.
Three inches	5s. 1d.	9s. 5d.

The two latter depths are only suitable for private roads, court yards, or stables.

We now proceed to consider, generally, the advantages and disadvantages of wood pavements.

The noise produced by the rattling of carriages over the unnecessarily broad paving stones of the metropolis is absolutely deafening, and the most striking advantage of the wood pavement, especially to a stranger in London, is the absence of noise where it is laid down. At the line of separation of the two kinds of road, the thundering clatter of a thousand vehicles at once ceases, and is succeeded only by a low, subdued rumble.

The pedestrian leaning on the arm of a friend, and exerting his lungs, at "the top of their bent," in the most private and confidential conversation, is compelled to reduce his voice to a whisper, so instantaneously, that he cannot avoid expressing his admiration of the system. If such be our feelings, as mere street passengers, we may endeavour to estimate the great boon conferred upon the shopkeeper, or other inhabitant (whose days, and nights, and years are passed upon the spot,) when wood pavement is substituted for stone. The quietness of wood pavement is also a great advantage in the neighbourhoods of public offices; and in the vicinity of churches situate in great thoroughfares, where the noise of granite pavement is such that it is only by closing the street that divine service can be decently performed.

Another advantage will doubtless be a great saving in the wear and tear of carriages.

The durability of wood pavement has been urged as one of its advantages; but, as I have already stated, facts are not given by its advocates to warrant any conclusion favourable or otherwise.

I am of opinion that it will not last nearly so long as granite; at any rate, that which remains to be proved cannot be adduced as an advantage.

Another advantage is, that the concrete foundation prevents the rising of the subsoil, and there is consequently very little dust or mud generated; this, however, would be the case, to a great extent, with *stone pavement*, were it similarly constructed.

The *slipperiness* of wood pavement is an objection that has hitherto baffled all the ingenuity of its advocates. During several visits to the metropolis, since its introduction, I have carefully watched it, and never without additional evidence, that it is dangerous for passengers, and *absolutely destructive* to horses.

I have stood sometimes an hour or more in the same place, when the surface was wet, (and the constant watering keeps it almost continually so) and have seen hundreds of horses that came dashing along with a firm, bold step upon the stones, slip about, and tremble as with an ague, when they came upon the wood. It is no uncommon occurrence to see three or four horses down at once; and it is a fact that horse-soldiers, passing from one part of London to another, dismount, and lead their horses over the wood pavement. At a meeting of the City Commissioners of Sewers, in February last, Mr. Deputy Godson stated that he had seen *twenty* horses down at one time upon the wood pavement in Newgate street.

In Gracechurch street, in April last, I saw, among others, a brewer's dray with a team of four very powerful horses; they began to slip as soon as they came upon the wood, and continued along the street in a manner that would have alarmed any timid person; first one, and then another of them sprawling about, and the shaft-horse, with the dray pushing behind him, would occasionally slide a yard, or more, without lifting his feet. In company with two friends, I carefully observed the extent of the slide when horses trotted briskly without falling, and found it to vary from *four* to *eight* inches, where the road was wet, every foot they set down.

Those who consider the temperament of the horse, and also how the upper bones of his anterior extremities are jointed in an angular direction, apparently to break the force of concussion, will conclude that he was intended to tread firmly, and that he is seriously injured when he cannot do so.

Various attempts have been made to remedy the evil. It has been proposed to keep wood pavements covered with sharp sand; this would not only be an expensive and doubtful remedy, but would revive all the evils of mire and dust in their worst form. In Russia, it is said, a covering of pitch and sand has been tried, but as the result is not at the same time stated, its success must be considered more than doubtful. It would be more expensive than sand alone, and liable, in some degree, to the same objection. All kinds of chamfering and grooving of the blocks have beeen tried with very partial success; and patents have been obtained for horse-shoes, professedly adapted to wood pavements, some of which cannot be obtained under twenty shillings per set. But horses are not always upon the wood, and when they travel upon the stones, the toothing of their shoes is worn off in a very short time.

As a consequence, therefore, of the slippery nature of wood pavement, there is, and will be, a great increase in the consumption of horses.

Neither can it be denied, when horses are continually slipping and falling, that there is danger to carriage-passengers.

Many members of this Society have witnessed, and probably experienced, the difficulty of crossing the crowded thoroughfares in London: upon the stone pavement, it is a hazardous exploit, but upon the wood doubly so: to slip would be fatal.

It has been urged by a talented writer in *Blackwood's Magazine*, that if the mud of granite pavement were kept off the wood, slipperiness would be effectually cured; but every *lad* knows that he can slide upon a wet plank: it is moisture, whether as mud, or in any other form, that makes wood pavement slippery: and the shower that produces granite mud falls at the same time upon the wood pavement.

All other objections to wood pavement are of minor importance, but ought not to be entirely omitted.

The great expense of laying it down is an objection; and is increased by the necessity for a substratum of concrete.

The blocks vary sometimes in quality, and as the concrete allows no escape for water, the pavement has been found in some cases slightly decayed in a very short space of time.

It is well known that Sir Peter Laurie has made himself conspicuous for his opposition to the wood pavement. He has condemned it in his magisterial capacity; he has argued the subject at vestry and other meetings; and has originated and presented numerous memorials against it; but at the same meetings, the memorials in its favour, from the inhabitants of great thoroughfares, requesting that it might be laid down, have been so many and so numerously signed, that he has only been laughed at as a worthy successor of Don Quixote.

I have carefully examined the reported proceedings of many such meetings, and have found that, although Sir Peter Laurie was borne down by a great majority of votes, his arguments were frequently stronger than those of his opponents.

The advantages of wood pavements are all on the side of the parishioners, who vote, either personally or by representatives, for its introduction into their respective neighbourhoods; while the disadvantages are all on the side of the passengers upon it, few of whom are voters in the parish or vestry where the question is to be settled. The poor horses, whether resident or non-resident, have no votes.

A numerical majority of interested parties is anything but an infallible tribunal; and though it may be safely predicted that the present rapid extension of wood pavements must and will inevitably go on, yet, until some plausible remedy for its slipperiness be discovered, we ought to admire the integrity, the fearlessness, and the humanity of Sir Peter Laurie.

Thus have I set before the Society, to the best of my ability, the mode of construction, the original cost, the durability, the advantages and the disadvantages of modern carriage-ways.

I have treated the subject in a plain manner: as a matter of business which concerns us all. It has been my wish to afford information, rather than to amuse. Whether or not the paper has interested the meeting, is not for me to say; I have my doubts; but that the subject is one of great importance, I am sure no one here will deny.

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